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Dihadron Correlation in the eA program at an Electron Ion Collider

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BNL EIC Science Task Force

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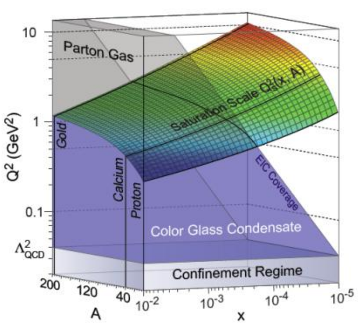
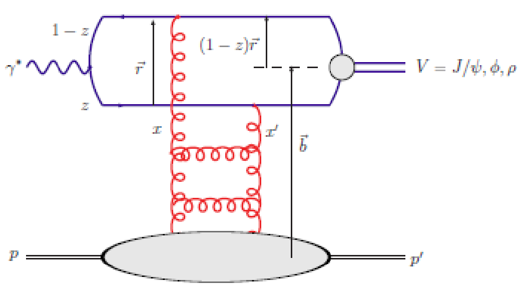
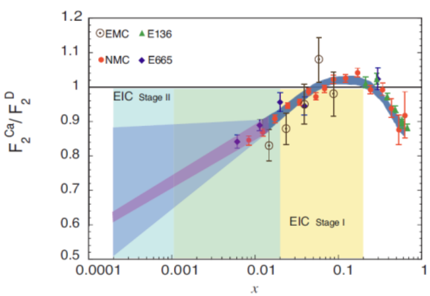
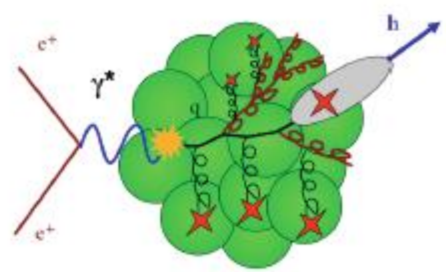
Motivation

- Electron-Ion (eA) program will investigate the nuclei structure with great precision
  - Probing gluon dynamics, establish the existence of the saturation regime.
  - Obtain a spatial image for the nucleus.
  - Precisely measure nuclear parton distribution function in a wide range.
  - Study the parton propagation and hadronization in cold nuclear medium.
- Dihadron correlation is a key measurement in the eA program to help us explore the saturation physics.

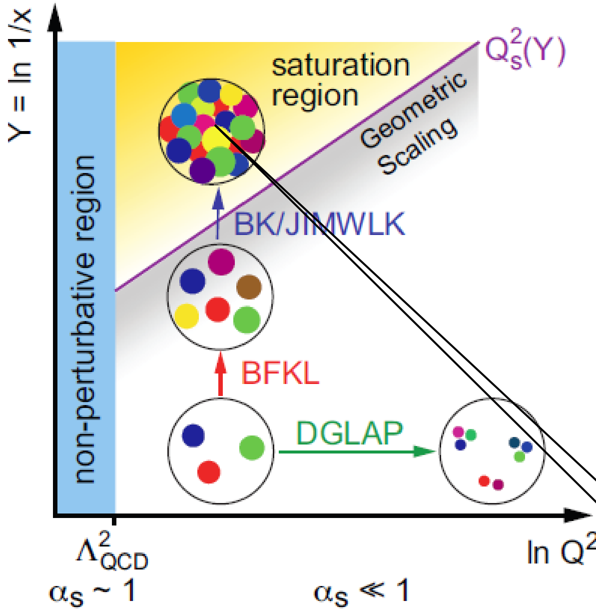


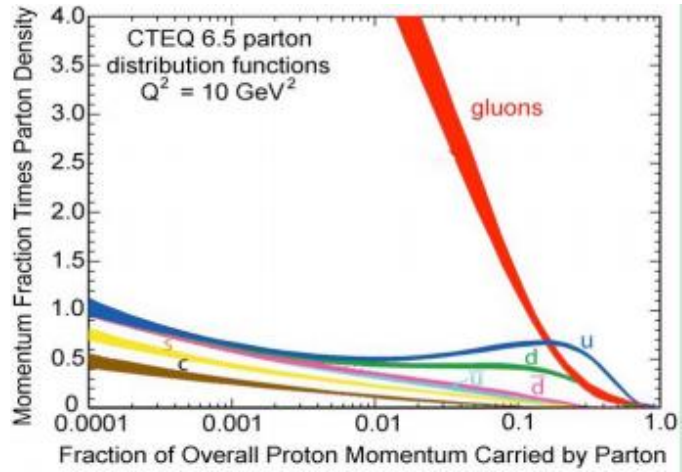




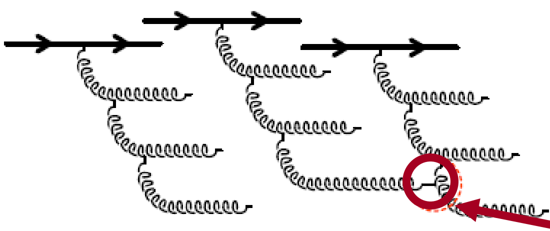


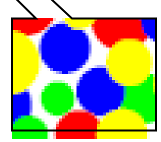
Explore the saturation regime



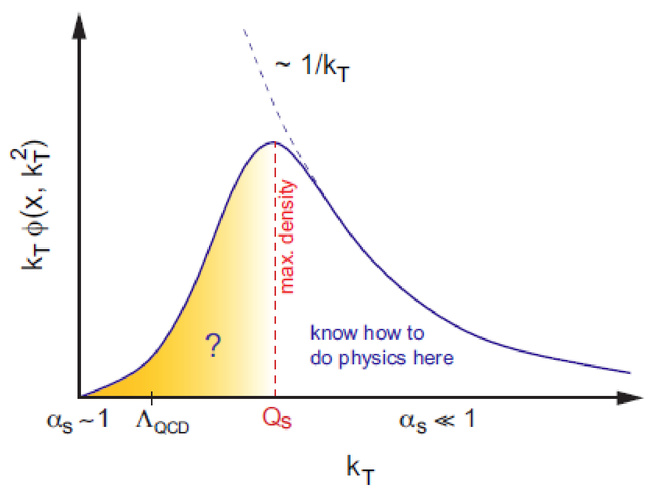


$$Q_s^2(x, A) \simeq Q_0^2\, A^{1/3} \left(\frac{x_0}{x}\right)^{\lambda}$$





$r_T \sim 1/k_T$



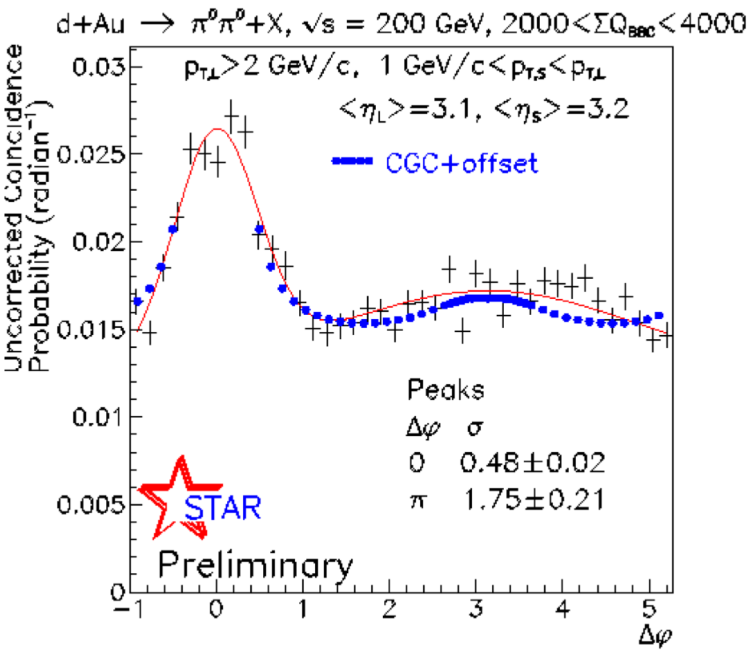
Mechanism for gluon saturation

What can we learn from dihadron correlations

Conditional Yield (CY)

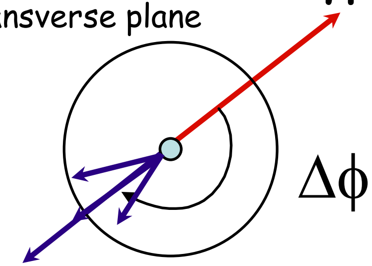
$$CY = \frac{1}{N_{trig}} \frac{dN^{assoc}}{d\Delta\varphi}$$

arXiv:1008.3989v1



Beam view
or transverse plane

trigger(usually leading pt)

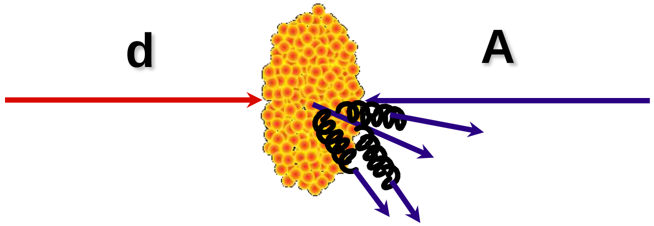


associate

Nearside peak: delivers jet fragmentation information from final state

Awayside peak: related with the medium kt kick from initial state

With high gluon density



Multiple emissions decorrelate of away-side as predicted by saturation model

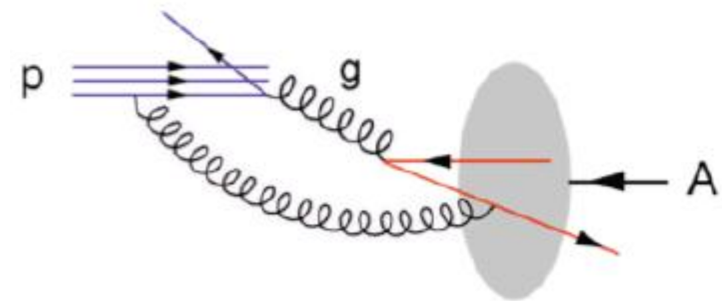
Dihadron correlations at eRHIC

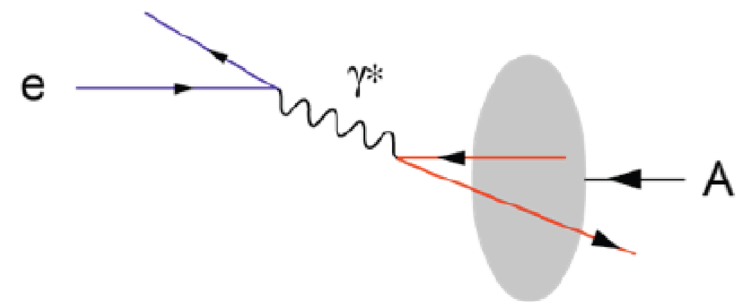
Electron Ion Collider (EIC):

- Extract the spatial multi-gluon correlations and study their non-linear evolution

Advantage over p(d)A:

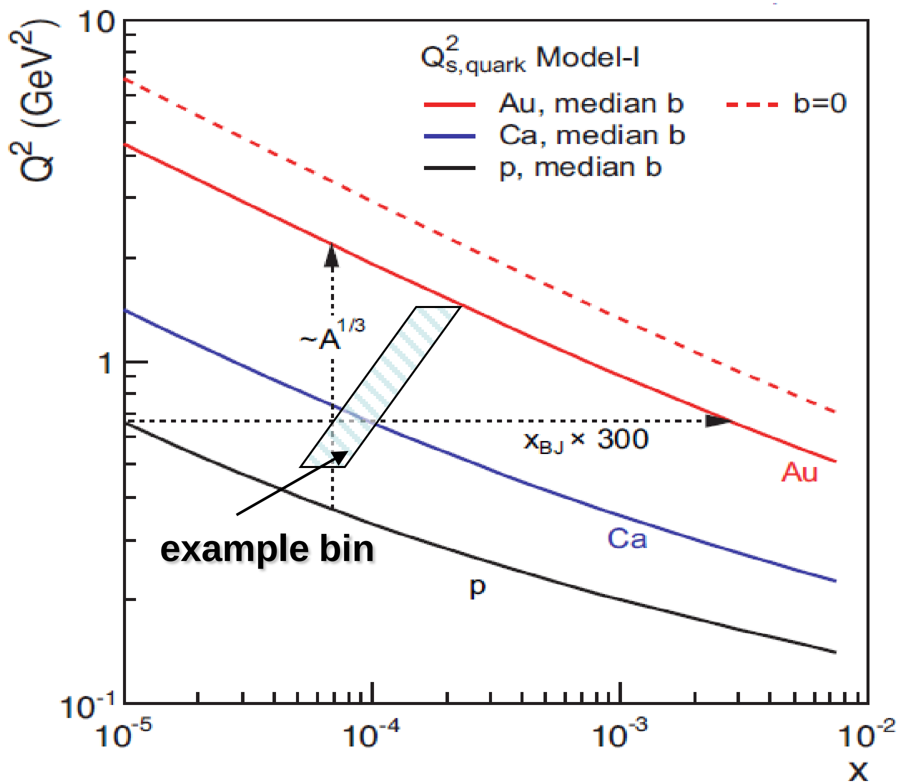
- Control initial/final state
- eA experimentally much cleaner
  - no “spectator” background to subtract
- Access to the exact kinematics of the DIS process (x, Q^2)



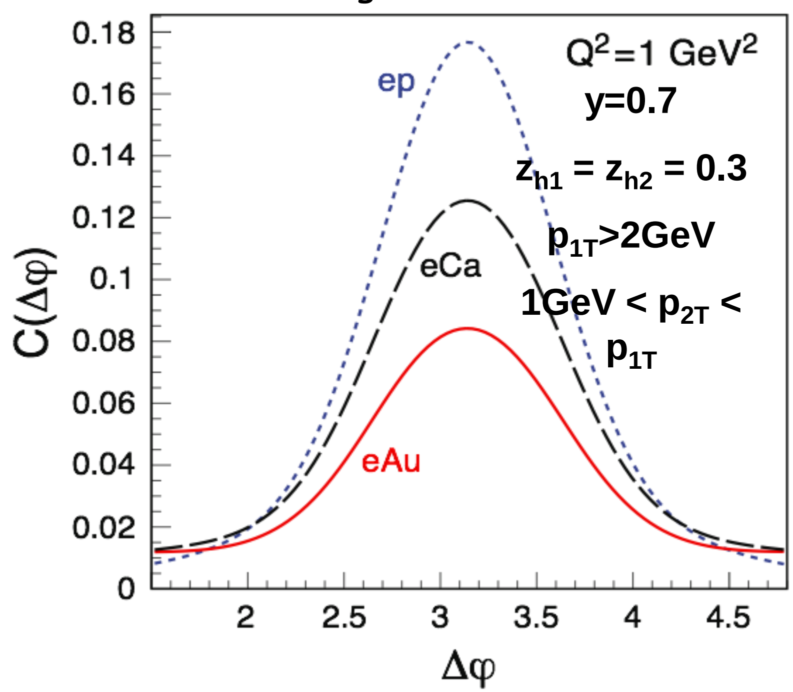


theoretical prediction from Saturation/CGC model

Pocket formula: $Q_s^2(x) \sim A^{1/3}\left(\frac{1}{x}\right)^{\lambda} \sim \left(\frac{A}{x}\right)^{1/3}$



Xiao, Dominguez, Yuan 2011/2012



Bin:0.5<Q^2<1.5GeV^2, 0.6<y<0.8
<x>=1.01×10^{-4},
<y>=0.69,
<Q^2>=0.84GeV^2,

Our Monte Carlo approach for dihadron correlations in eA/ep

A hybrid model consisting of DPMJet and PYTHIA with nPDF EPS09.

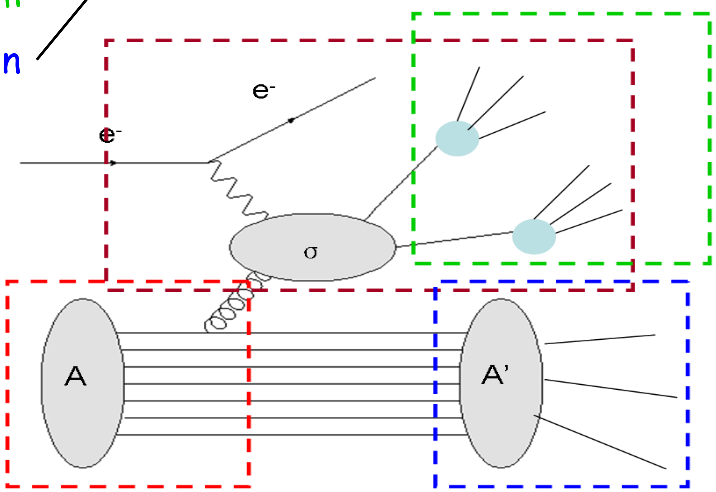
Nuclear geometry → **DPMJET**

Nuclear PDF → **EPS09**

Parton level interaction, parton shower and jet fragmentation → **PYTHIA**

Energy loss effect for cold nuclear medium → **Energy loss module by Salgado&Wiedeman**

Nuclear evaporation → **DPMJET**



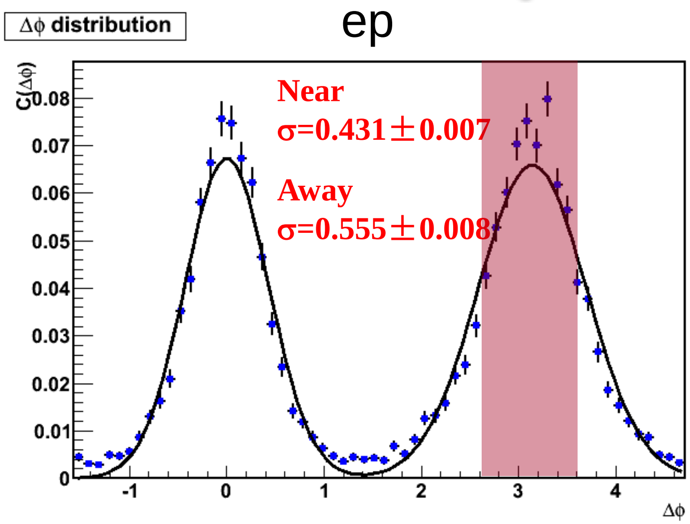
Decorrelation of dihadron:

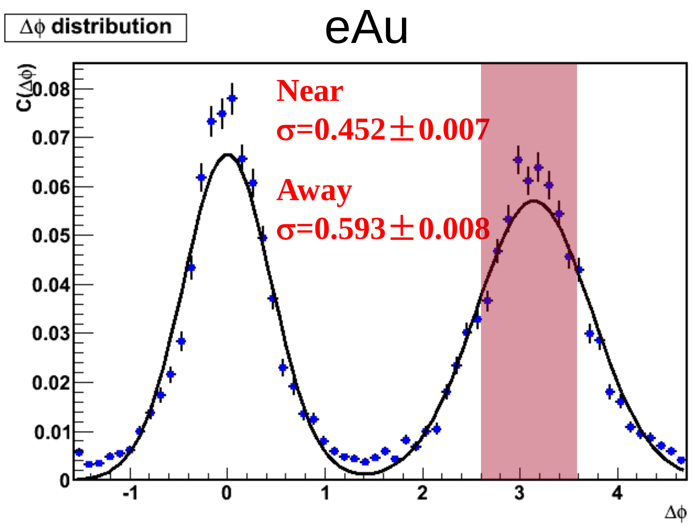
- Higher order effects (parton shower)
- Noncollinear effects (intrinsic k_T)
- Fragmentation process (Jetset)

- Multiple scattering
- Saturation

A non Saturation model

Compare ep and eA





30+100 GeV 10M events

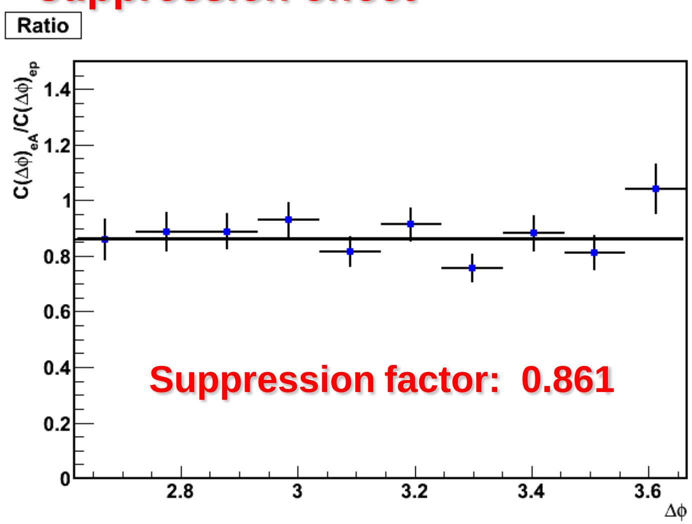
0.5<Q2<1.5, 0.6<y<0.8

|η|<4 (2<θ<178 deg),

$p_T^{Trig}>2$, $1<p_T^{Asso}<2$

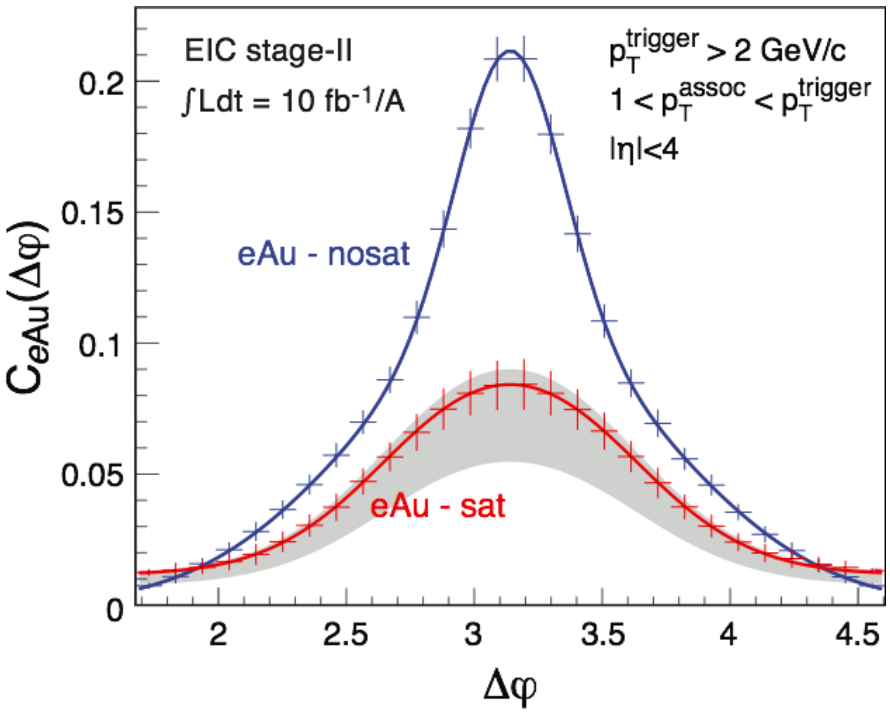
$0.15<z^{Trig,Asso}<0.45$

Nuclear PDF gives no strong suppression effect



Compare with prediction from saturation model

EIC white paper



Saturation expectation: back to back peak washed out by multiple gluon interactions.

No saturation: peak persists without saturation ep->eA.

Saturation and No saturation are easy to resolve with a few months running.

Saturation model well constrained

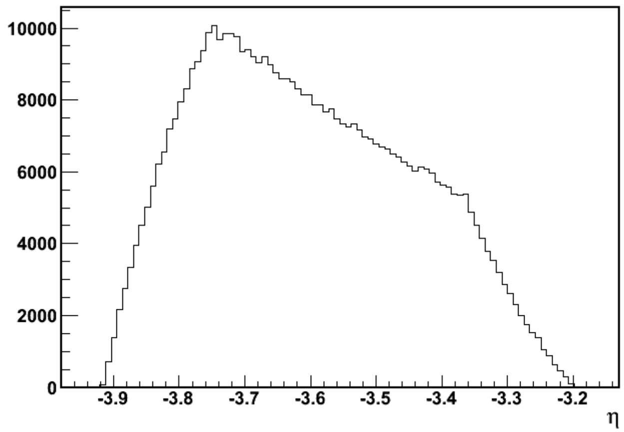
Summary

- Dihadron correlation is sensitive to the saturation physics.
- A generic Monte Carlo generator developed based on pQCD calculation in vacuum with flexible nuclear effects on.
- eRHIC offers unique opportunities to study the saturation physics precisely.
- Provides the knowledge of initial state of heavy ion collision.
- More interesting topics we can do with an Electron Ion Collider -> Refer to T.P.Burton's talk

Back up

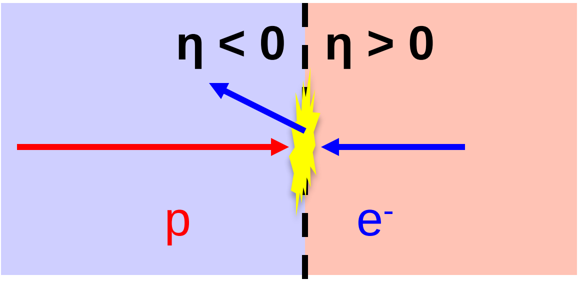
Detector requirement

Scattered electron pseudo-rapidity



For ep 30x100:

Bin : 0.5<Q2<1.5, 0.6<y<0.8
Scattered e^- : <E>=9.00GeV,<θ>=176.51°



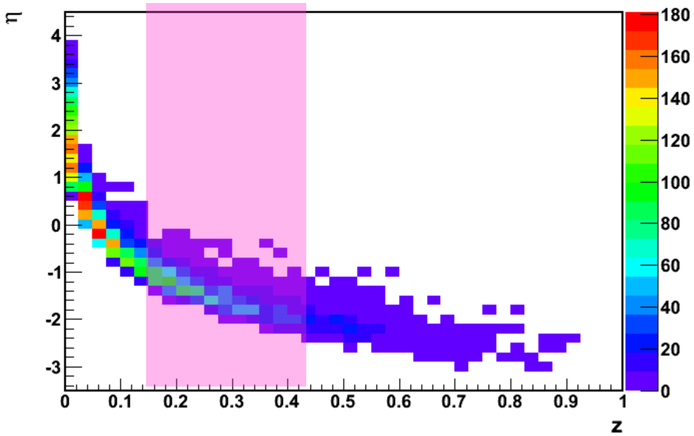
Trigger/associate particle cut:

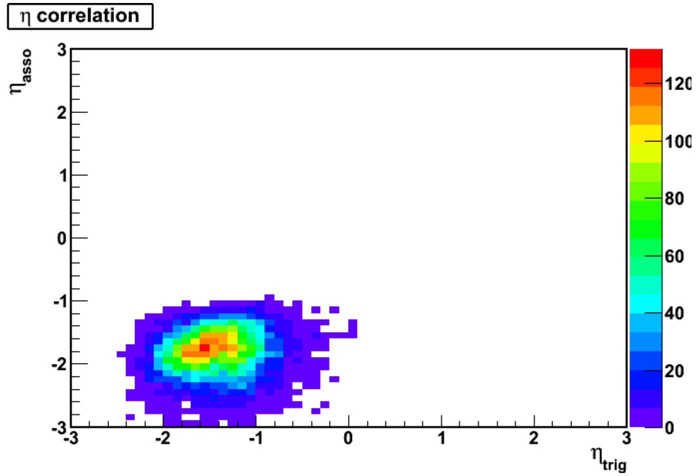
$|\eta|<4$ ($2^\circ<\theta<178^\circ$),

$p_T^{Trig}>2$, $1<p_T^{Asso}<2$

$0.15<z^{Trig,Asso}<0.45$

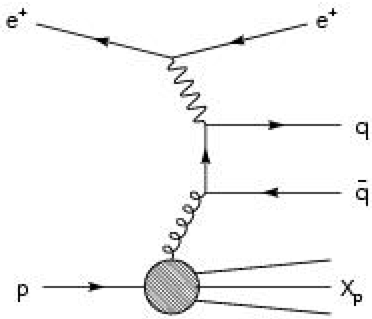
Leading particle span

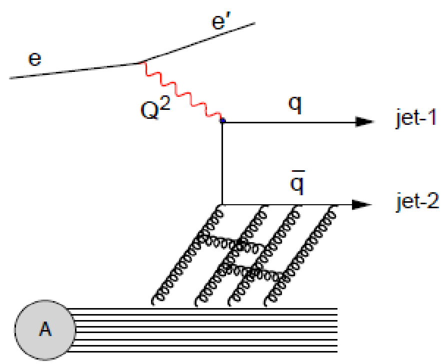




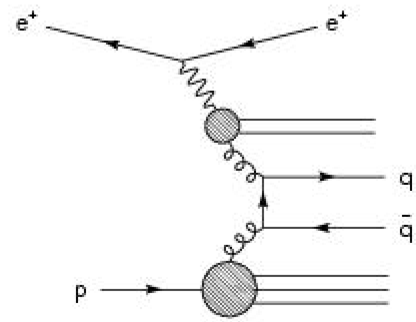
Dihadron correlation at eRHIC

PGF



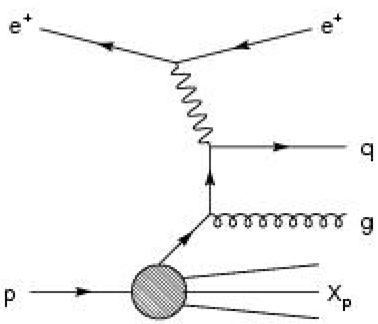


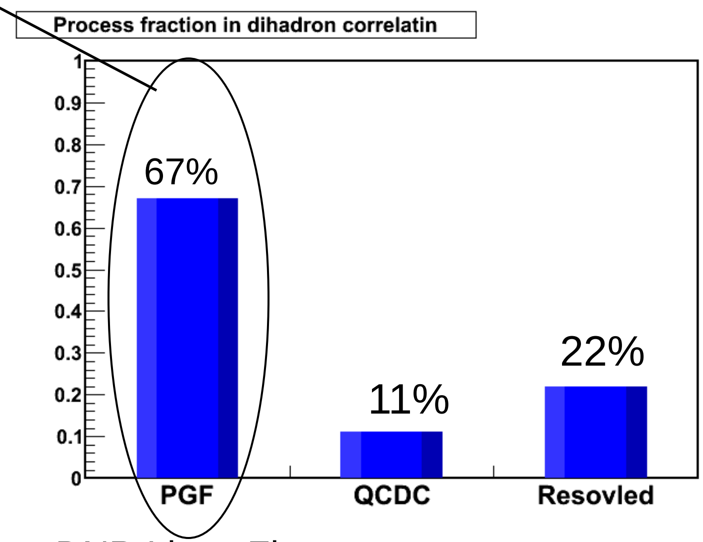
Resolved



Dominant process: Photon Gluon Fusion (PGF), sensitive to the property of strong gluon field.

QCDC





from PYTHIA simulation